Title: Transition from Natural Gas to Manufactured Gas

Creators: Demorest, Dana James, 1882-1958

Issue Date: Nov-1923

Publisher: Ohio State University, College of Engineering

Citation: Ohio State Engineer, vol. 7, no. 1 (November, 1923), 9-11, 26.

URI: http://hdl.handle.net/1811/32851

Appears in Collections: Ohio State Engineer: Volume 7, no. 1 (November, 1923)

Transition from Natural Gas to Manufactured Gas

PROF. D. J. DEMOREST, *Professor of Metallurgy*

PUBLIC statement of the fact that our natural gas supply is limited and that it will be but a few years until it is entirely inadequate to meet the demands for gas have been made many times. It is an inconvenient and unpleasant thought and many people have not faced the facts, but it has now gotten to the point where the situation must be faced. It has been faced squarely in several places and solved and we need not fear it. It is merely a problem requiring sober and calm thought, careful, painstaking engineering and adequate financing. Of course, we can just say, "We are through," and give it up, but that, of course, cannot be entertained for a minute because the gas men have a duty to perform, their investment to protect and are too game to be licked.

The problem then is: How can we not only maintain our supply of gas but increase it to meet the increasing demands for gas. The solution of this problem also involves the answer to some other questions. Let's get them down in black and white before us—

1ST. NEW SOURCES OF GAS

(A) Additional wells. You know how thoroughly the rock has been explored and how little more gas can be expected. There is undoubtedly some more to be tapped.

(B) Manufactured gas.

(a) Coal gas. Coal, of course, does not contain gas except in traces, but it does contain organic compounds altered from the organic matter of ancient vegetation. This organic material undergoes decomposition when heated away from air, resulting in a lot of new compounds, some of which are gaseous, some liquid and some solid. When a good gas coal is heated in a closed retort or oven it produces a multitude of products classified and in amounts as given below per ton of coal used:

Gas—11,000 cu. ft. of 550 B.t.u. per cu. ft.
Tar—95 pounds.
Ammonium sulfate—25 pounds.
Benzol—2.1 gallons.
Toluol—0.56 gallons.
Xylol—0.33 gallons.
Crude solvent—0.4 gallons.
Coke—1,400 pounds or 70% of the weight of the coal used.

The coal gas has a B.t.u. value per cu. ft. of 50% of that of natural gas, but has a higher temperature of flame—hence heats more rapidly per B.t.u. released.

The analysis of coal gas is—

CO_2, 2.2; Illuminants, 2.6; O_2, 0.3; CO, 6.9; H_2, 47.8; CH_4, 34.2; N_3, 6.0; B.t.u., 560; Sp. Gr., 0.42.

This is a very acceptable and useful gas.

(b) Water gas. When coal is heated for the production of coal gas there is left about 70% of its weight as coke. Some of this coke will be fine breeze and not good for water gas-making or for sale but it is very satisfactory for producer gas-making to heat the coal gas ovens or retorts. This will take about 300 pounds, leaving, say, 1,050 pounds for water gas-making. It takes about 35 pounds of coke to make 1,000 cu. ft. of water gas, thus generating 30,000 cu. ft. of blue gas of the following composition—

CO_2, 3.5; CO, 43.5; O_2, 0.6; H_2, 47.3; CH_4, 0.7; N_2, 4.4; B.t.u., 300; Sp. Gr., .56.

This gas has a B.t.u. value of about one-third of that of natural gas, but it also has a higher flame temperature than natural gas.

(c) Mixing Coal and Water Gas. If coal is completely gasified in the two steps—coal gas-making, water gas-making—and the gas from the retorts and water gas generators are mixed (There is no difficulty in this.) there will be obtained about 41,000 cu. ft. of mixed gas per ton of coal used. This mixed gas will have B.t.u. value of 365 B.t.u. per cu. ft. and a total of 15,000,000 B.t.u. in the gas per ton of coal used, or 60% of the heat value of the original coal. Of course, smaller amounts of water gas may be mixed with the coal gas and get a higher B.t.u. mixture. Thus in England and Canada a 50-50 mixed gas of coal gas and water gas is used, getting a 450 B.t.u. gas. Blue water gas can be enriched by "cracking oil" in a carburetted water gas set but this greatly increases the cost of the raw materials used per 1,000 cu. ft. of gas, and oil is getting dearer every year.

(d) Oil gas made by partially burning crude oil is being used at Los Angeles, producing a gas of 550-750 B.t.u. per cu. ft., and mixing it with natural gas successfully. But oil is much cheaper in Southern California than in Ohio.

2. ENRICHING MANUFACTURED GAS WITH NATURAL GAS

This is merely a matter of a little engineering. It has been done easily in a number of places, notably in California.

Coal gas alone is quite rich enough if made from first class gas coals. But if made from poor coals it will need to have its B.t.u. value increased and this is still more true when the coke made in the coal gas retorts is afterward gasified in the water gas generators and the water gas mixed with the coal gas. As pointed out above, if all the coke so made is gasified and mixed with the coal gas the resulting mixture will have a B.t.u. value of 365-385 B.t.u. per cu. ft. This is too lean at least for our present day, and will have to be enriched. The oil method of enrichment, as already stated, was by use of the gas from "cracking" oil. But here we have already at hand and for a long time to come a natural product for enriching lean manufactured gas—that is natural gas. The ordinarily accepted B.t.u. standard for manufactured gas is 525-550 B.t.u. per cu. ft., although as mentioned above it has been found quite all right in some places in England and Europe and Canada to use a 450 B.t.u. gas. If we completely gasify coal by the two steps described above and get 40,000 cu. ft. of 365 B.t.u. gas it will require 11,500 cu. ft. of natural gas to mix with it or enrich it to bring the gas up to the usually accepted standards for manufactured gas; or, roughly, the natural gas will be one-fifth of the mixture when a good gas coal is used and all the coke is gasified as water gas. Of course, if a poorer coal is used more natural gas would be required for enriching and whether a good gas coal or a poor gas coal is used will depend upon the relative costs of these two. Ohio coal will give about the same amounts of gas as the rich gas coals but of a lower B.t.u. and hence require more natural gas for enrichment.

3. Burner Troubles

A gas appliance that has been designed to use natural gas will not necessarily use manufactured or mixed gas successfully. However, it has been found that the changes and adjustments necessary are easily made and inexpensive. If the mixed gas has about the same specific gravity that natural gas has the change can be easily made without adjustment except perhaps for the amount of air used.

The gases used have the following specific gravity:

Coal gas, .43; Water gas, .65; Mixed Coal and Water, .50; Natural gas, .55.

Since the rate of flow of any gas through an orifice is inversely proportional to the square root of its density; hence, if we keep the specific gravity the same the same amount of gas will flow with a given pressure no matter what kind of gas we use.

The specific gravity of natural gas is about 0.55; of coal gas, 0.45; of blue water gas, 0.65; of mixed coal gas, 0.50, and when enriched with natural gas as previously mentioned about 0.525. This is so near the specific gravity of natural gas that the gas burner orifice used for natural gas will pass very nearly the same amount of mixed gas as of natural gas (7% more of mixed gas) under the same pressure, getting, of course, only 50% as many B.t.us. per minute but also getting a higher temperature of flame.

The air required to burn a gas is nearly proportional to its B.t.u. value. To burn one cu. ft. of the gas requires the amount of air required in the table below, using no air excess. Of course, in actual practice about 20% excess air is needed. The air supply for the burners would need to be adjusted in about the following proportions:

Natural gas, 10.0; Coal gas, 5.0; Water gas, 2.4; Coal-Water gas, 3.2; Enriched Coal-Water gas, 4.7.

The tests made by and the experiences of the Los Angeles Gas & Electric Company shows there is no great difficulty in changing from natural to a mixture of natural and manufactured gas, provided the gas companies use reasonable diligence and care in educating the consumers before the change is made. The tests made at Los Angeles were quite extensive and prove quite conclusively that no great anxiety need be had over the change—if the gas companies show reasonable care in this matter.

4. Disposition of By-Products

The by-products of manufactured gas-making are coke, tar, ammonia sulfate, light oils. These all have a ready market which, of course, fluctuates as do all markets. The most valuable of these by-products is the coke. If the market for coke is good it may pay better to sell the coke as such instead of making water gas from it and erect more coal gas retorts and ovens to increase the supply of gas. That is one of the advantages of the coal-gas. water-gas combination plant—if the coke market is good the water gas generators can be shut down or slowed down and the coal gas retorts pushed for all they are worth; when the coke market is poor the retorts can be slowed down and the water gas sets operated, using, of course, natural gas to enrich it. The coke makes the most desirable solid domestic fuel known with the possible exception of anthracite, when the house furnaces are properly equipped. The sale of the coke will be a comparatively easy matter, and as already remarked, may be more profitable than making it into gas. This, of course, involves a greater outlay of capital for retorts.

Ammonium-sulfate is widely used for many purposes and readily saleable, the price being about 1.3c per lb.

Tar is coming more and more into use—its present price running about 5c per gallon.

Light oil is the source of our benzol, toluol, xylol and solvent naphtha, which are the basic materials of so large a percentage of the explosives and dyes.

Our civilization absolutely must have these by-products of the coal gas industry, and there will always be a market for them, sometimes, of course, not so profitable as at other times. When the Ohio Natural gas companies get into the manufactured gas business one of the results will be the establishment of chemical industries which use tar, ammonia and light oils as raw materials and this will, of course, increase the demand for these.

5. Raw Materials

There is no region in the world more advantageously situated for making manufactured gas, as far as raw materials are concerned, as Ohio. West Virginia, Kentucky and Western Pennsylvania have the finest gas coals in the world and Ohio has an enormous amout of coal which, while not as high grade as these other coals, yet with natural gas as an enriching agent it may be more profitable to use some of our Ohio coals than more expensive coals from our neighboring states. This will depend largely upon the success which we may have in dry cleaning our coals so that the gas will be low in sulfur and the coke low in ash. Tests made at the Ohio State University indicate that this is promising, but more tests need to be made to get a final answer on this subject.

We are near the great refractory and steel making centers of the country, hence the cost of constructing the gas plants will be a minimum.

6. Choice of Kind of Plant

The kind of gas works erected will depend upon a good many factors. Some of them are:

1. Cost of Gas-Making.
2. Size of Operation or Amount of Gas to be Made.
3. Market for Products, Especially Coke.
4. Location of Plant (Near Large City or at Mine).

1. Cost of Gas Making.—This, of course, depends upon many factors but the cost of the raw materials and the selling price of the by-products balance to a satisfactory degree.

From this it will be seen that from the point of view of manufacturing costs aside from investment charges coal gas is the ideal manufactured gas and it is of very high quality. Even counting in investment costs it is the cheapest per 1,000 cu. ft. if operated the entire year. Oil gas is slightly cheaper per 100,000 B.t.u. when made in connection with water gas. One great trouble with oil gas is the uncertainty of the oil supply. Water gas costs about the same to make per 1,000 cu. ft. as coal gas, but costs nearly twice as much per 100,000 B.t.u. when coke is charged at $10 per ton. If, however, the coke is charged at the same cost as the net return realized by sales, say, $8, the cost per 1,000 cu. ft. of blue gas is about 4c less. If the coke is made at the mines where the market for it is poor and is charged at the same price as gas coal, say, $6 per ton, the blue gas will cost about 27c per 1,000 cu. ft., or 7c less than coal gas, but about the same per 100,000 B.t.u. Of course, if the gas works are located at the mines the cost of coal will be less, but the income on the coke will also be less. In this connection it must be remembered that one must ship two tons of coal to get one ton of saleable coke, but the freight rates are not the same—the rate on coke is nearly twice that on coal. Further, it is very undesirable to have coke broken up by long shipment, while breaking coal which is to be used for gas-making does little or no harm. Also the cost of transporting the manufactured gas by pipes is an item.

2. Size of Operation.—If the plant is to be a big one, say, big enough to supply Columbus, Akron or Dayton, there is no doubt in my mind of the kind of plant to be used. It should be a coal gas plant big enough to supply enough coke so that the combined coal gas and water gas will be of such volume as to supply the city when enriched with the natural gas available. Owing to the high investment charges of a coal gas plant it should be only of such size that it will run 365 days per year, part of the water gas plant being shut down or slowed down during the summer and coke stocked. Then during the winter the rate of water gas-making is increased as the demand calls for it and, of course, with it the supply of natural gas for enrichment. I think the gas companies will find it profitable to make more coke than they need for gas-making and educate the people to burn coke in their furnaces, buying it in the summer when the supply is greatest. The natural gas producing companies will, of course, require a large amount of manufactured gas and hence will be in the position of a company producing only for a large city—they will need a large plant or plants and hence will use the coal-gas water-gas combination.

The position of a small company producing for a small community is different. If natural gas is available in sufficient amount it will be cheapest probably to put up a simple blue-water gas plant and enrich with natural gas. To make a gas of the standard usually required in the eastern cities it will be necessary to mix about one cu. ft. of natural gas with 2.25 cu. ft. water gas. If there is not enough of a supply of natural gas the water gas will have to be enriched partially at least with oil, or in my opinion still better, a battery of retorts would have to be installed. But it is likely enough that the gas business will develop as the electrical busines has—elimination of small generating plants and building big central stations, transmitting at high pressure.

3. The kind of plant installed will depend considerably upon the market for by-products, especially coke. If the demand for coke is active, one would erect a coal gas plant of sufficient size to supply the demand. I feel quite certain that one of the big developments of the change to manufactured gas will be the increased use of coke as a domestic fuel.

If the demand for metallurgical coke is strong the type of coal gas plant selected would probably be a coke oven plant, but otherwise more likely some type of coal retort. If the gas supply of Ohio were all made in coke ovens they would produce about 10,000,000 tons of coke, which is more than all the blast furnaces of the state can use. Retorts make a better grade of gas than coke ovens and make a very fine grade of coke for domestic use.

The market for other by-products is pretty steady. The world can't get along without ammonia. Neither can it get along without wheat, but somettimes there is an over supply of wheat and prices fall. I feel, however, that the demand for ammonia fixed as sulfate for fertilizer is just in its infancy and will expand as our population grows and the soil needs to be more productive. We are in an era of good roads and to my mind there is only one satisfactory kind of intercity road—that is, a heavy base of crushed stone or concrete with a tarvia surface. Brick or cement surfaces are too slippery. Also the uses of tar products for chemical manufacturing are increasing. I look to see the business greatly increase in Ohio. These things all point to a coal gas plant with byproduct recovery as the logical type of gas plant, supplemented by water gas generators using coke. The market for benzol fluctuates with the gasoline market.

4. Location of the Plant.—The kind of plant selected will depend somewhat on the location of the plant. If the plant is located near a large city where the market for coke is good, one would build a coal gas plant of larger capacity than if located at the mine. In other words, the retort capacity would be larger and the water gas capacity smaller if the plant were located near a large city, with an active demand for domestic coke. If the plant is located in a region of large metallurgical coke demand, as, for instance, Cleveland or Youngstown, it would possibly be wise to select the oven type of coal gas plant. If, on the other hand, the plant should be located near a place where coke is cheap it would be more economical to operate a straight water gas plant, enriching with natural gas as already mentioned. The development of the water gas generator using coal instead of coke is somewhat changing the situation, although the cost per 100,000 B.t.u. is 50% greater when making water gas from coal than when making coal gas, even though the cost per 1,000 cu. ft. is slightly less. If the location of the plant is in a field where the demand for gas fluctuates very widely, then a coal gas plant alone would hardly be satisfactory because the retorts can't be easily hurried while a water gas plant is more flexible. A coal gas plant can't be shut down and allowed to remain idle except at considerable expense, because of: 1st, the large capital charges; 2nd, it must be kept hot even if not making gas; 3rd, it requires about ten days to cool down and an equally long time to start up. A water gas generator can be started up in a few hours.

7. Location of Gas Works

Should the gas works be located near the point of consumption or at the mines near a pipe line? The answer depends largely upon transportation problems. If the plant be located at the mines then one must either use all the coke made in the coal gas plant by gasifying it in water gas sets, in which case the advantage of disposing of the coke for domestic fuel when the price makes it more profitable to do so than to gasify the coke, is lost, or one must be at the disadvantage of having to ship the coke, which breaks it more or less, and further the freight rate on coke is nearly twice that on coal. On the other hand if the plant be located at the point of consumption then the freight cost of the coal is a large item since about two tons of coal must be used for every ton of merchantable coke used. This may be more than balanced by the advantage of the shorter coke shipment and saving in the transportation of the gas. If, however, the company is serving several communities this latter advantage would be largely lost unless a works were erected at each considerable center of consumption, which might not be desirable.

If there is any question of the ability of the long distance pipe line to carry the manufactured gas, this, of course, would justify a decision not to put the plant at the mines.

It is very likely that if the coke is to be sold for domestic purposes some West Virginia or Kentucky coals will have to be shipped to the plant to mix with the Ohio coals to make the coke of proper strength. This subject needs a lot of investigation, as we do not yet know just how highly to evaluate our Ohio coals for gas making. It is quite possible, though, that per dollar of expense in coal it will be found that with natural

(Continued on page 26)

TRANSITION FROM NATURAL TO MANUFACTURED GAS

(Continued from page 11)

gas for enrichment it is economy to use some of our native coals. This problem is also wrapped up in the problem of cleaning coal to reduce the ash and sulfur. We are equipped at the Ohio State University with the most complete and modern appartus for investigating on a practical scale the results of cleaning and gasifying coals of any place in the country.